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ARMSTRONG LABORATORY

DEVELOPMENT AND EVALUATION OF AEROMEDICAL EVACUATION MEDICAL EQUIPMENT SECURING DEVICES

Thomas E. Philbeck, Jr., Master Sergeant, USAF

CREW SYSTEMS DIRECTORATE
Brooks Air Force Base, TX 78235-5000

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Richard J. Knecht

RICHARD J. KNECHT, Lt Col, USAF, NC
Project Scientist

F. W.

F. WESLEY BAUMGARDNER, Ph.D.
Supervisor

RMiller

RICHARD L. MILLER, Ph.D.
Chief, Crew Technology Division

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13. ABSTRACT *(Maximum 200 words)*
The United States Air Force (USAF) aeromedical evacuation system, under the command and control of Air Mobility Command (AMC), has a large inventory of medical equipment items that are procured for use on military aircraft. The items must have the capability to be adequately secured within the aircraft, in most cases in the immediate vicinity of the patient. Aeromedical research technicians from the Armstrong Laboratory, Aeromedical Research Function have designed several devices that may be effectively used for securing many of the various medical equipment items likely to be brought aboard the aircraft. It was concluded that there is a slight potential for hazard presented by the protruding thumbscrews on the original Horton Bracket, and it is relatively heavy. The Waters Bracket will probably require relatively high fabrication cost due to design complexity, and also cannot be used on C-130 aircraft. However, provided the devices are fabricated and used as specified in this report, all 5 devices are safe and an effective means for securing selected aeromedical evacuation medical equipment items.

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DEVELOPMENT AND EVALUATION OF AEROMEDICAL EVACUATION MEDICAL EQUIPMENT SECURING DEVICES

BACKGROUND

The United States Air Force (USAF) aeromedical evacuation system, under the command and control of Air Mobility Command (AMC), has a large inventory of medical equipment items that are procured for use on military aircraft. The items must have the capability to be adequately secured within the aircraft, in most cases in the immediate vicinity of the patient. During the past 3 years approximately 30 additional medical equipment items have been tested and evaluated by the USAF Armstrong Laboratory's Aeromedical Research Function (ARF); either under first article testing, or terms of a technology exchange agreement (TEA) with a manufacturer.

For first article testing, contract specifications have stated that the medical items must have securing mechanisms that allow securing to the North Atlantic Treaty Organization (NATO) litter whose sides have poles measuring 3.8 cm (1-1/2 in.) in diameter. Unfortunately, several items ***will secure to the litter pole,*** just as specified, ***but to nothing else on the aircraft.***

There are several problems associated with securing items to the litter pole. The most serious problem is the possibility of an item being bumped and falling, especially if used in this manner on an aircraft with crowded aisleways, such as the C-130 or C-141B aircraft (Fig. 1). If an item falls, it could present a hazard to crewmembers and patients and could cause damage to the item itself.

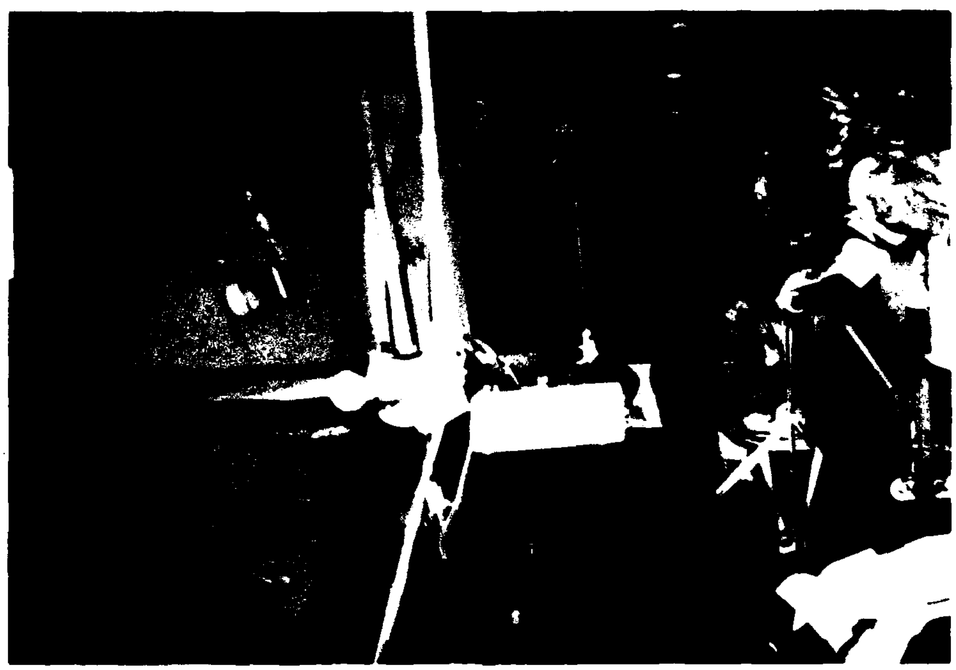

Figure 1. Aisleway of C-141B with pulse oximeter attached to NATO litter.

Likewise, injury or damage could result if the device is mounted to the litter and accidentally knocked off during enplaning or deplaning. Another problem is visibility. If a device is mounted on the litter at the same level as the patient, which is usually waist high or lower, the medical crew has problems monitoring the indicators on the devices, especially while sitting in a crew seat.

Other items are evaluated under a TEA. They usually are standard hospital fare, designed to be placed on a bedside table or shelf, or on rolling stands. Therefore, while the items are considered safe and secure in a medical treatment facility, most of them have no provisions at all for mounting in the hostile mobile airborne environment of an aircraft.

Medical aircrew members have, for years, tried to find or make the perfect device, such as a bracket, to mount and secure all medical equipment items on all the aircraft. Eventually, they realized that such a device did not exist and was not practical to make.

Nevertheless, aeromedical research technicians from the ARF have continued to evaluate the problem of securing medical equipment designed to fit on the handles of a NATO litter. Several devices were designed, developed, and evaluated that may be effectively used for securing many of the various medical equipment items likely to be brought aboard the aircraft.

The purpose of this report is to document the rationale for and historical development of those securing devices. Secondary purposes are to provide relevant technical data and make recommendations concerning making the devices available to the aeromedical evacuation community.

DESCRIPTIONS

1. Original Horton Bracket.[1] The original intent of the bracket was to improve securing methods for the Baby Bird infant ventilator, which had been tied to the aircraft floor on its wobbly wheeled stand, and the IMED Model 928 infusion pump, which could not be adequately secured without several bulky litter straps. The bracket was designed to be mounted vertically, with each end secured to either 2 in-place litter pole handles, or in 2 litter stanchion clamps. (If used in litter stanchion clamps, the accompanying aluminum plugs must be used to interface the bracket and the clamps.) The bracket is made of 3.18 cm (1-1/4 in.) tubular stainless steel, and is 17.8 cm (7 in.) wide. The length is adjustable, between 61.0 and 109.2 cm (24 and 43 in.), to accommodate the variable spacing between litters. See Figure 2.

[1] Conceived and designed by CMSgt Melvin S. Horton, who has since retired from the USAF. He conceived the bracket in 1986 while at the 9th Aeromedical Evacuation Squadron, Clark AB, Republic of the Philippines. Using the hand-drawn design plans provided by Chief Horton, 16 brackets were made, primarily of stainless steel cut from scrapped medical cabinets and shelves, found by Chief Horton and the author at the salvage yard at Clark AB. The brackets were fabricated by the 376 Tactical Airlift Wing sheet metal shop at Clark AB.

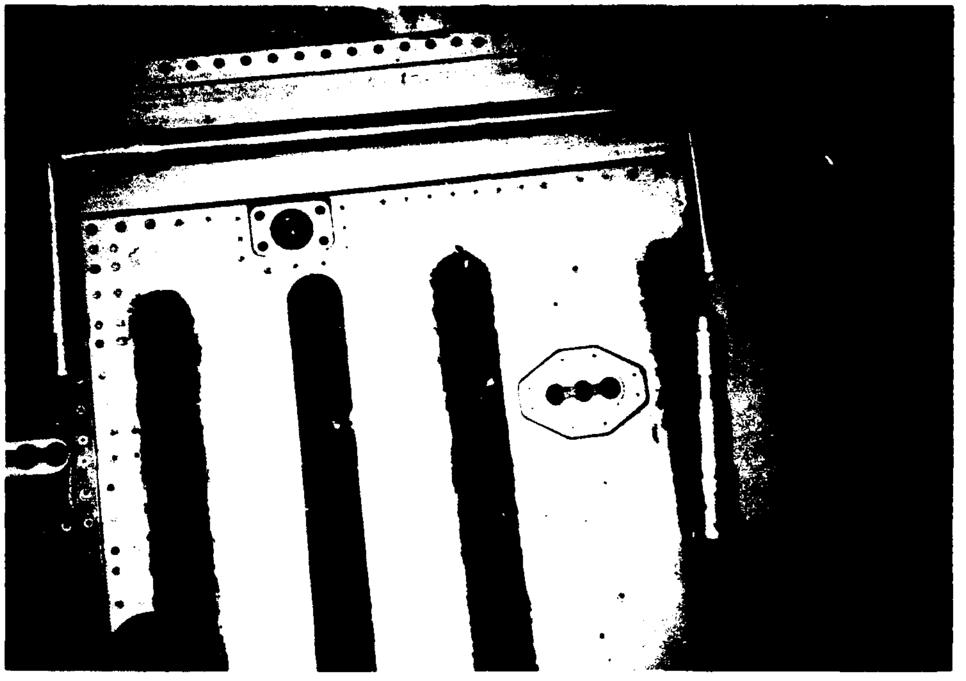

Figure 2. Original Horton Bracket on floor of C-141B aircraft.

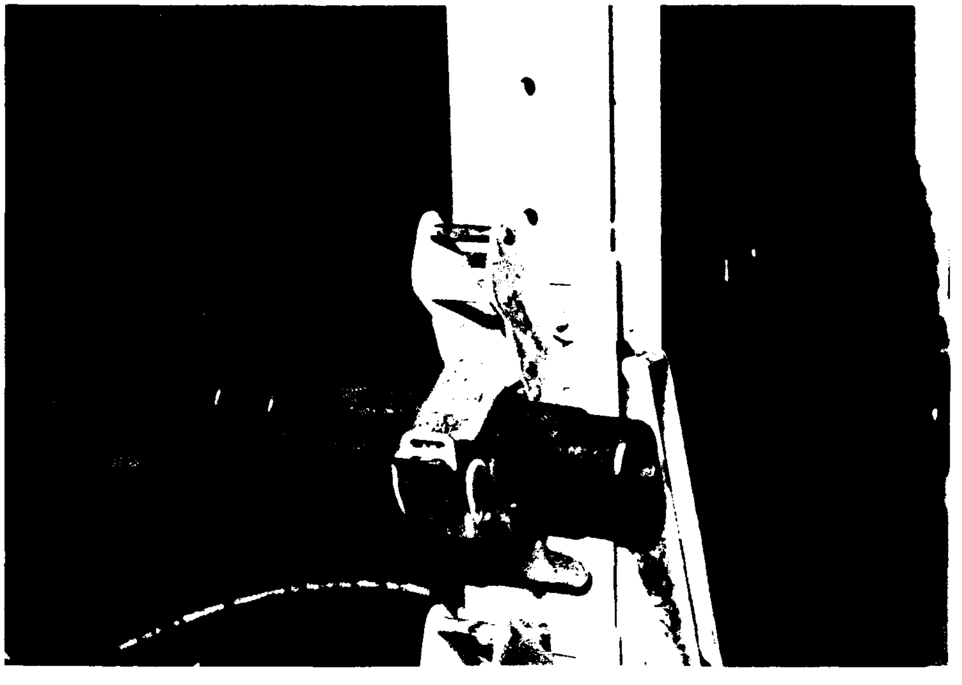

Figure 3. Aeromedical Pole in C-130 litter stanchion.

2. Aeromedical Pole.[2] This device was conceived and designed to secure the Biochem 1040A pulse oximeter and Medical Technology Products 1001a infusion pump without attaching to a NATO litter. The pole is hollow, made of aluminum, and is 22.9 cm (9 in.) long and 3.2 cm (1-1/4 in.) in diameter. It is designed to snugly fit into the litter stanchion clamps on the C-130 and C-141B aircraft, as well as into the cantilever arm clamps on the C-9A aircraft. When the pole is secured in this manner, medical equipment items designed to fit the NATO litter can be mounted to the pole. Armstrong Laboratory Research Engineering and Fabrication Division (DOM) provided the finished product. See Figure 3.

3. Waters Bracket.[3] This device is made of aluminum, has overall dimensions of 20.3 cm (8 in.) wide x 17.15 cm (6-3/4 in.) high x 12.7 cm (5 in.) deep. It secures into the litter stanchion pole tracks on the C-9A and C-141B aircraft, using a locking mechanism similar to that on the C-9A litter cantilever arm. Medical equipment items designed to fit the NATO litter can be mounted to the pole. DOM provided the finished product. See Figure 4.

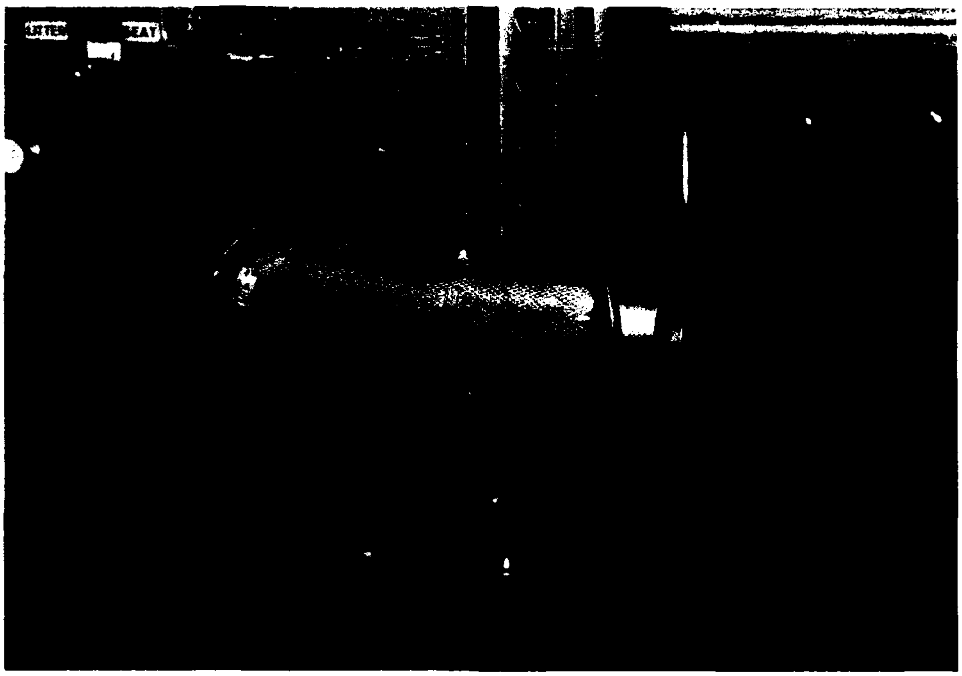

Figure 4. Waters Bracket attached to C-9A litter stanchion.

4. Modified Horton Bracket. During the delayed evaluation of the original Horton Bracket, several design changes were suggested. DOM made a new prototype (hereafter referred to as the "Modified Horton Bracket"), incorporating those design

2 Conceived and designed by the author.

3 Conceived and designed by SSgt Thomas W. Waters, Armstrong Laboratory, Brooks AFB, TX.

changes. With the exception of the following, the Modified Horton Bracket is essentially the same as the original Horton Bracket (Figs. 5 and 6):

a. Aluminum Fabrication. The bracket was made lighter 2.27 kg (5 lb) by constructing it with aluminum, rather than the stainless steel used with the original.

b. Incorporation of Aeromedical Pole. Aeromedical poles replaced the solid aluminum plugs, for installation onto the litter stanchion using the litter clamps (C-130 and C-141B aircraft) or cantilever arms (C-9A aircraft). When not required for use in this manner, the Aeromedical Poles can be independently used to secure medical equipment.

c. Thumbscrew Replacement. The thumbscrews located on each end of the bracket (used to tighten the bracket in-place) were replaced with large round knobscrews, which allowed easier gripping and tightening. A small chain was connected between the knobscrews and the bracket to prevent loss if a knobscrew became completely unscrewed. The thumbscrew in the center of the bracket which allowed length-adjustment, was replaced with a collar-type tightening mechanism.

d. Length Adjustment. The overall length was shortened to 52 cm (20.5 in.) so that it can be installed on the end of a single litter.

e. The surface of the long center portion was knurled, to better prevent slippage and provide a better gripping surface for securing medical equipment items.

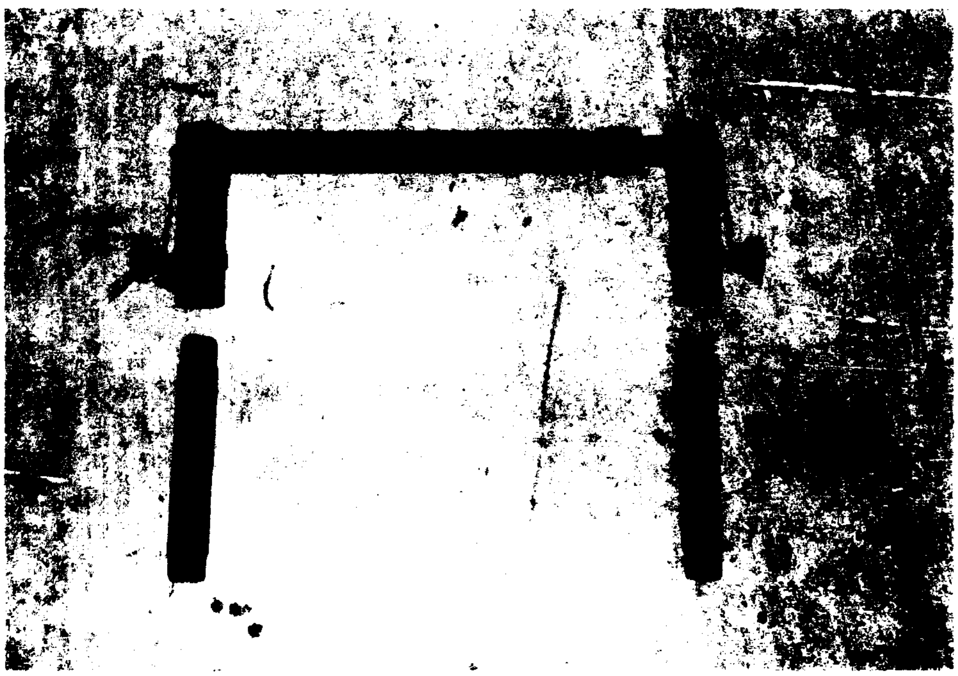

Figure 5. Modified Horton Bracket with Aeromedical Poles detached.

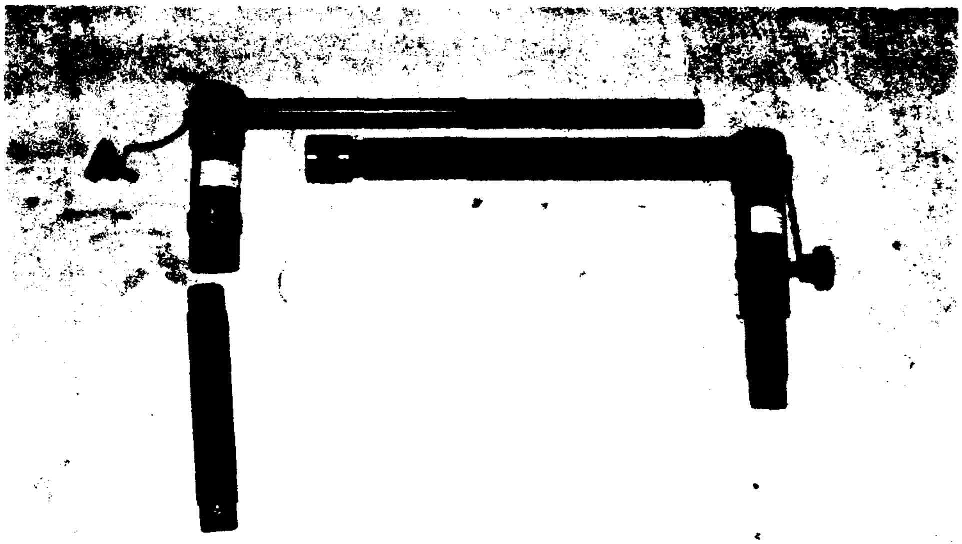

Figure 6. Modified Horton Bracket with center section disassembled.

5. Waters Shelf.[4] A device was conceived that could be secured to litter stanchions of any of the 3 aeromedical evacuation aircraft. It is basically an aluminum shelf with a 30.48 cm x 33.02 cm (12 in. x 13 in.) surface for securing virtually any medical equipment item that weighs 22.7 kg (50 lb) or less, and will sit on its rubber non-slip surface. It is 22.86 cm (9 in.) high, with a triangular collapsible support base. Nylon straps, with ratchet-type tightening mechanisms, secure the shelf to the aircraft litter stanchion. Adjustable nylon straps, with plastic quick-release snap buckles, secure medical items to the shelf. See Figure 7.

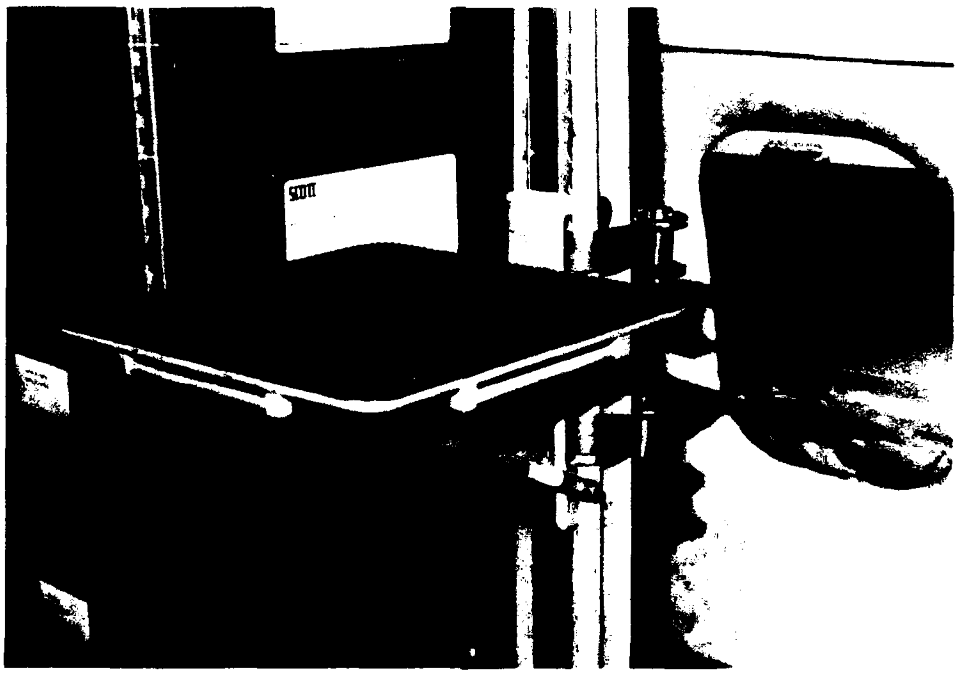

Figure 7. Waters Shelf in place on C-9A stanchion.

[4] Conceived and designed by SSgt Thomas W. Waters, Armstrong Laboratory, Brooks AFB, TX.

METHODS

Using the Aeromedical Research Function Procedures Guide (1), ARF personnel developed a testing protocol that covered safety and human factors issues during testing and evaluation of the devices. Proper functioning was verified by vibration testing, form and fit on aeromedical aircraft mock-ups, and actual airborne feasibility evaluations.

Vibration

To simulate aircraft conditions for these devices and future projects, a test setup was specially devised and constructed by in-house personnel. The setup consisted of a 99.06 cm (39.0 in.) section of an actual C-130 litter stanchion, situated perpendicular on a steel plate measuring 40.6 cm x 40.6 cm (16 x 16 in.). The setup was bolted directly to the vibration table. Two of the permanent sliding C-130 litter brackets were left in-place. Also, 2 removable sections of C-141B stanchion track were bolted to accommodate C-141B litter clamps and C-9A cantilever arms. See Figures 8 and 9.

Using MIL-STD-810D (2) as a guide, vibration testing consisted of random and sinusoidal waveforms on the X, Y, and Z axes, to test the devices construction, durability, and performance during worst-case vibration scenarios. The Unholtz-Dickey Vibration Control Console and Vibration Table at Armstrong Laboratory Technical Operations Division (DOJ) were used for the tests. The console and table were operated by technicians from DOJ, who programmed the control console for five 15-min cycles (5-500 Hz), totaling 75 min on each axis for the sinusoidal testing; and 30 min on each axis for the random testing. Before, during, and after the tests, visual examinations were conducted.

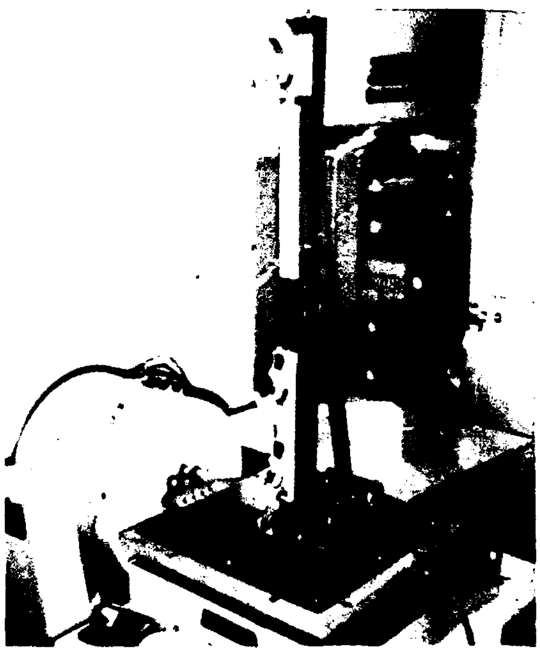

Figure 8. Litter stanchion vibration testing setup.

Figure 9. Litter stanchion vibration testing setup with original Horton Bracket attached.

The securing devices were installed and dead weight was applied as indicated. Dead weight, rather than actual medical equipment items, was used to avoid the possibility of damage to an operational piece of equipment. The amount of weight used was based on the realistic maximum weight of medical equipment likely to be attached to the securing devices while in actual use on the aircraft. The securing devices with dead weights were installed on the stanchion as follows:

1. Horton Brackets. Both the original and the Modified Horton Brackets were secured into a pair of C-141B litter clamps, which were locked into the litter clamp track. A suction canister with 1,200 ml of water was secured to the brackets. The suction canister setup, including the water, weighed 2,042 g (4 lb 8 oz).

2. Aeromedical Pole. The pole was secured into a C-141B litter clamp, which was locked into the clamp track. A Catalyst Research MiniOX III oxygen monitor securing bracket was attached to the Aeromedical Pole. Dead weight of 2719 g (5 lb, 15.9 oz) was taped to the securing bracket. The dead weight was used rather than a MiniOX III because of the minimal weight (less than 0.45 kg, or 1 lb) of the MiniOX III.

3. Waters Bracket. The bracket was locked directly into the litter clamp track. A Siemens MiniMed intravenous pump bracket was attached to the Waters Bracket. Dead weight of 6803.9 g (15 lb) was strapped to the MiniMed bracket.

4. Waters Shelf. The shelf was secured to the stanchion with the accompanying tightening straps. A 15.45 kg (34 lb) block of cement was placed on the shelf and secured with the accompanying buckle straps.

Evaluation on Aircraft Mockups

Form and fit evaluations were conducted on the C-9A, C-130, and C-141B aircraft mockups located in Bldg 820 on Brooks AFB, TX. The devices were evaluated as follows:

1. Horton Brackets.

a. The plugs/Aeromedical Poles were removed and the bracket was vertically secured onto the handles of 2 litters situated (one above the other) in the same litter stanchion. This procedure was done on each of the 3 aircraft mockups, with a Baby Bird infant ventilator and an IMED 928 infusion pump secured to the Horton Brackets (Fig. 10).

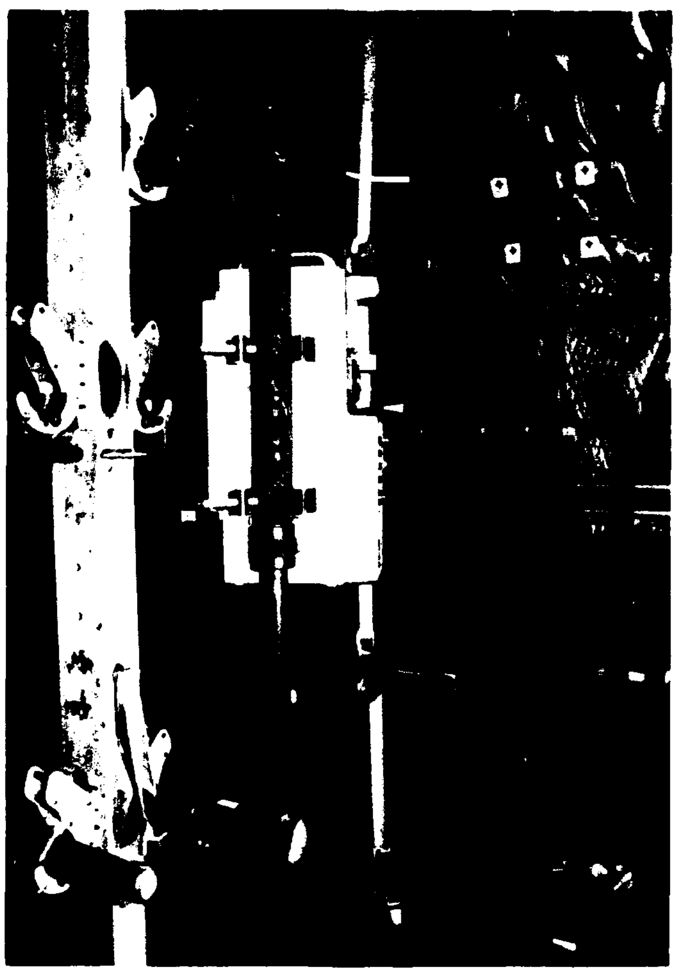

Figure 10. Modified Horton Bracket on C-130 attached to 2 litters with IMED infusion pump.

b. The plugs/Aeromedical Poles were left in-place in the brackets, with the brackets vertically secured into 2 litter clamps locked into stanchions on the C-130 and C-141B mockups, and into 2 cantilever arms locked into a stanchion on the C-9A mockup. A Baby Bird infant ventilator and an IMED infusion pump were secured to the Horton Brackets (Fig. 11).

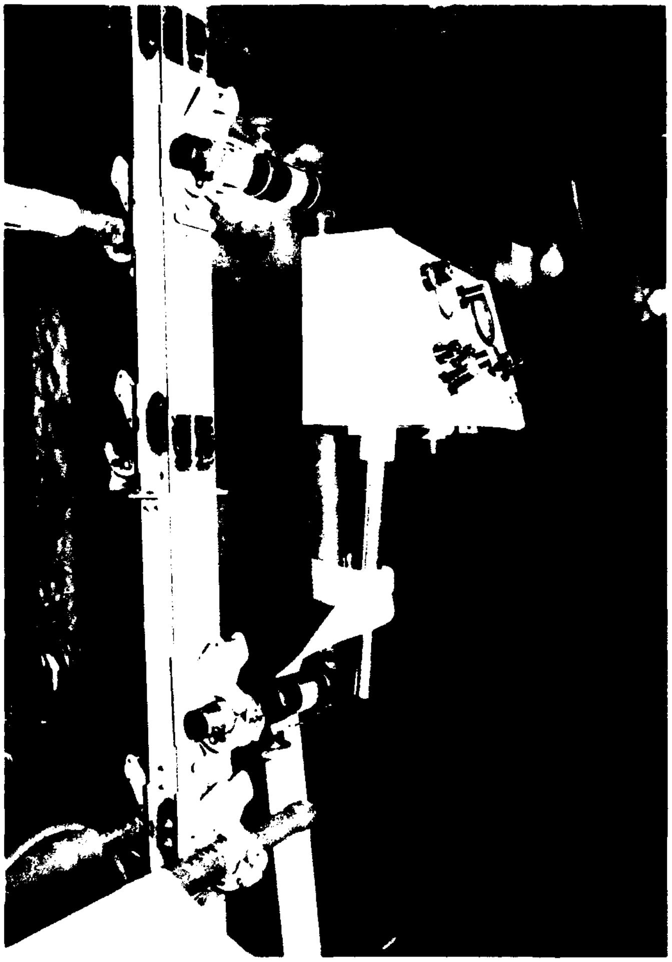

Figure 11. Modified Horton Bracket on C-130 attached to litter clamps with Baby Bird infant ventilator.

c. The bracket was vertically secured onto 1 litter handle and 1 litter clamp on the C-130 and C-141B mockup; and onto 1 litter handle and 1 cantilever arm on the C-9A mockup. A Baby Bird infant ventilator and an IMED Model 928 infusion pump were secured to the Horton Brackets.

d. The bracket was horizontally secured at the end of a litter, onto the 2 litter handles on all 3 mockups. A Biochem 1040A pulse oximeter was secured to the Horton Brackets (Fig. 12).

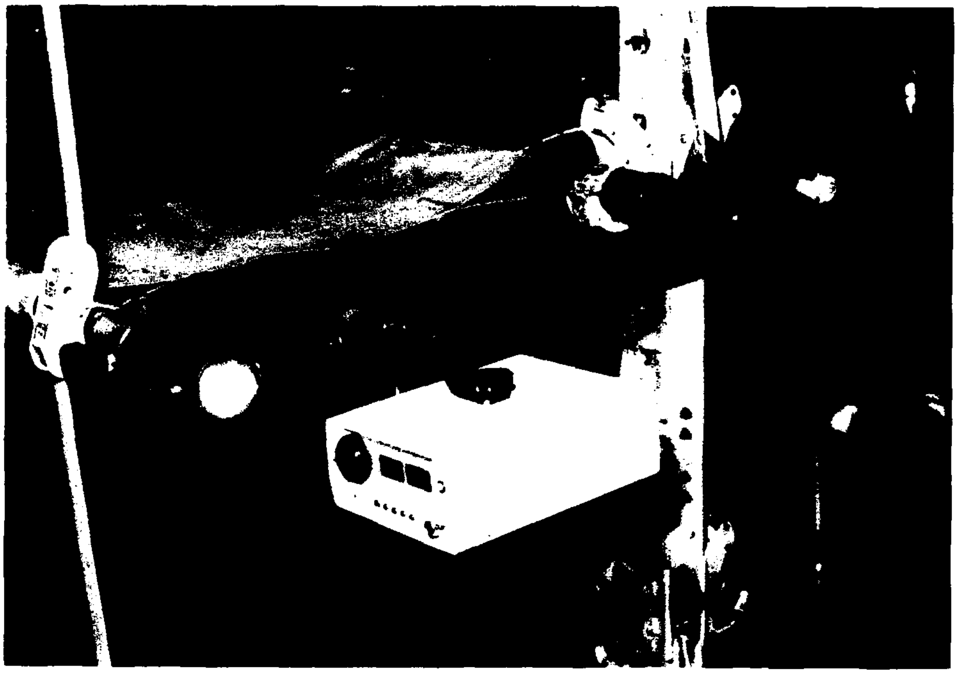

Figure 12. Modified Horton Bracket on C-130 attached to the end of one litter with Biochem pulse oximeter.

2. Aeromedical Pole. The pole was secured into litter clamps locked into stanchions on the C-130 and C-141B mockups, and into a cantilever arm locked into a litter stanchion. A Biochem 1040A pulse oximeter and MiniOX III oxygen monitor were secured to the pole (Fig. 13).

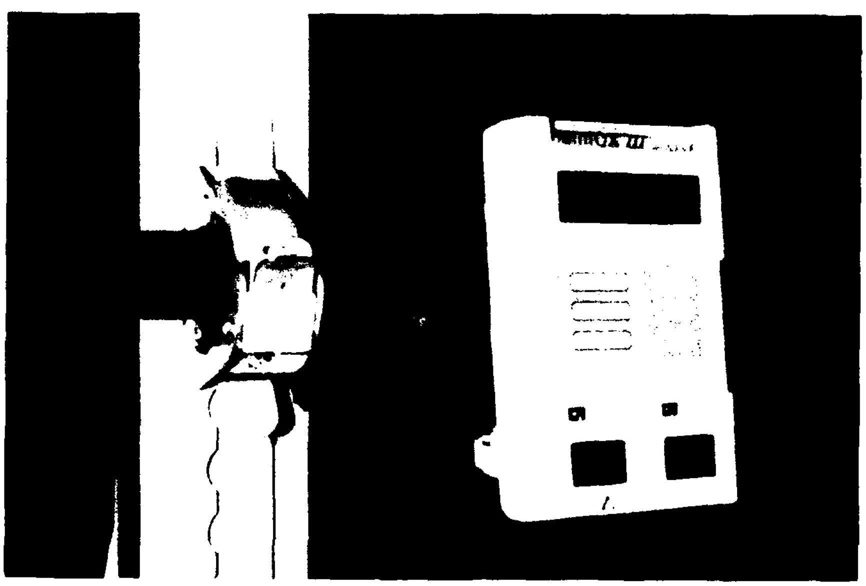

Figure 13. Aeromedical Pole on C-141B attached to litter bracket with MiniOX III oxygen monitor.

3. Waters Bracket. The bracket was secured to the litter stanchions in the C-9A and C-141B mockups. A Biochem 1040A pulse oximeter and MiniOX III oxygen monitor were secured to the pole (Fig. 14).

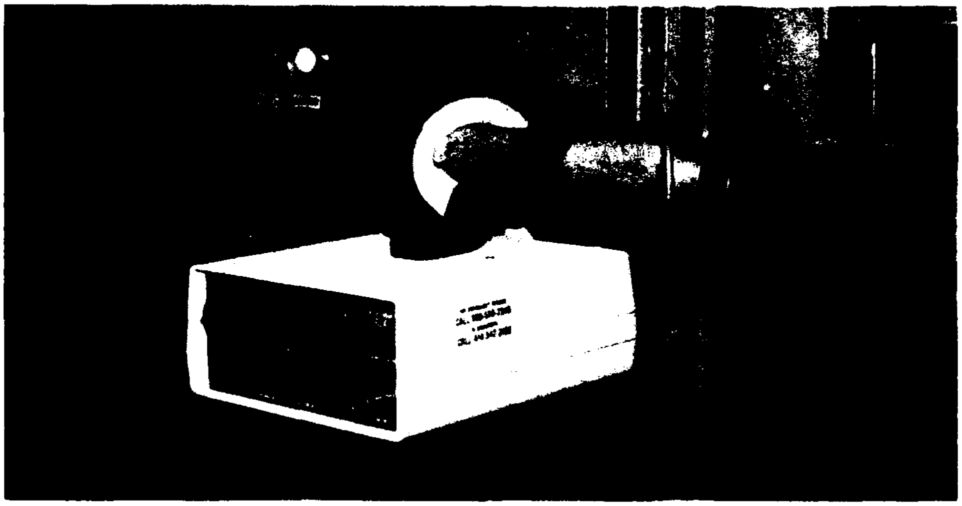

Figure 14. Waters Bracket on C-9A litter stanchion with Biochem pulse oximeter.

4. Waters Shelf. The shelf was secured to the litter stanchions in all 3 mockups. A Physio-Control LIFEPAK 10 cardiac monitor and Impact 308G suction pump were secured to the shelf (Fig. 15).

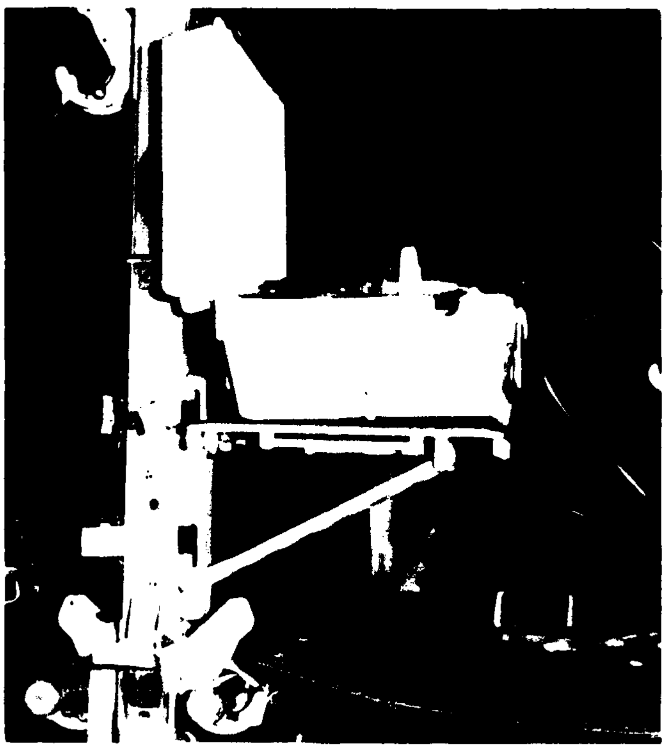

Figure 15. Waters Shelf on C-130 litter stanchion with Impact portable aspirator (Velcro securing straps not in-place).

Airborne Feasibility

To confirm and validate our in-house findings, the devices were evaluated on actual aeromedical evacuation missions, using standard aeromedical equipment.

1. Horton Brackets. Prior to our evaluation, the original brackets had been in use, without incident, on the C-9A, C-130, and C-141B airframes for several years in the Pacific aeromedical evacuation theater. Nonetheless, the original and modified versions were evaluated on both the C-9A and C-141B, using an IMED Model 928 infusion pump. On each aircraft the brackets were mounted using at least 2 methods.

a. They were mounted using the standard method, with 2 cantilever arms or litter clamps (Fig. 16).

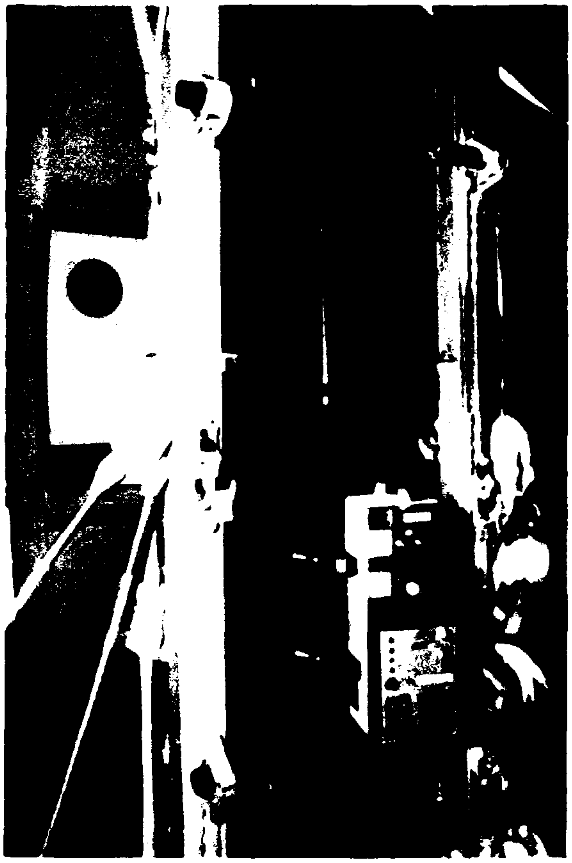

Figure 16. Securing the modified Horton Bracket on the C-141B using 2 litter brackets with IMED infusion pump.

b. They were mounted by removing the 22.86 cm (9 in.) plugs (or Aeromedical Poles in the case of the modified version of the bracket) from the ends, and securing the ends over 2 litter pole handles (Fig. 17).

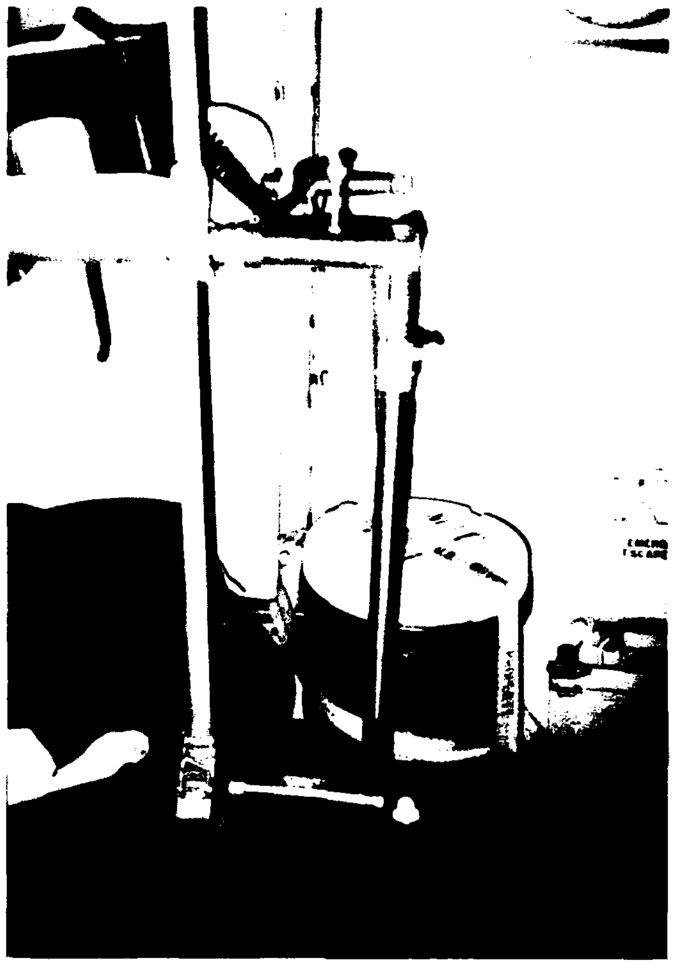

Figure 17. Securing the original Horton Bracket on the C-141B using the handles of 2 litters.

In addition, the modified version was mounted horizontally at the end of one litter, using the pair of handles at that end. A Biochem 1040A pulse oximeter was secured to the bracket.

2. Aeromedical Pole and Waters Bracket. These devices were evaluated on C-9A and C-141B missions. On the C-9A, the pole was clamped into a dedicated cantilever arm. The arm was placed on the stanchion above and in very close proximity, approximately 15.24 cm (6 in.), to a NATO litter (Fig. 18).

Figure 18. Aeromedical Pole on C-9A aircraft cantilever arm.

On the C-141B, the pole was clamped into the litter clamp locked into a stanchion. On both aircraft the bracket was locked directly into the litter stanchion tracks. For both devices on both aircraft, the Medical Technology Products Model 1001a infusion pump was installed.

4. Waters Shelf. As designed, the shelf was mounted directly to the litter stanchions on the C-9A and C-141B aircraft. On each airframe, the LIFEPAK 10 cardiac monitor and Impact 308M portable aspirator were secured to the shelf.

RESULTS

Vibration

All 5 devices passed vibration testing.

Evaluation on Aircraft Mockups

All 5 devices easily fit on each aircraft mockup, except the Waters Bracket which would not fit the C-130 litter stanchion.

Airborne Feasibility

1. Horton Brackets. Both the original and modified versions worked well, and were very practical for aeromedical equipment items requiring a vertical axis mounting surface. In the current aeromedical equipment inventory, these include the Catalyst Research MiniOX III oxygen monitor, Medical Technology Products Model 1001a infusion pump, Biochem 1040A pulse oximeter, IMED Model 928 infusion pump, Baby Bird infant ventilator, and any other item designed to be mounted on the NATO litter.

The modified version was also very effective in the horizontal position at the end of one litter. Drawbacks to the original Horton Bracket included the relative heaviness of the stainless steel material, 3.12 kg (6.9 lb), a slight potential for hazard presented by the thumbscrews, due to their protrusion, and its inability to be mounted horizontally on the end of one litter, due to its length (Fig. 19).

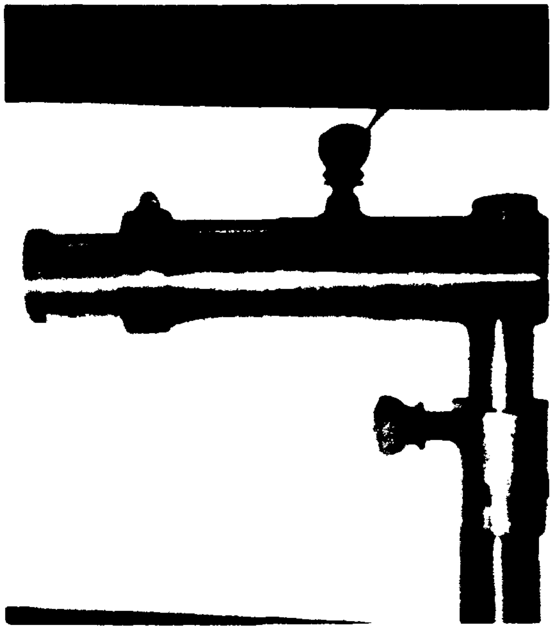

Figure 19. Original Horton Bracket thumbscrews.

The modified version was considered a significant improvement because of large tightening knobscrews (Fig. 20), connecting chain, lighter weight, knurled surface, and incorporation of Aeromedical Poles.

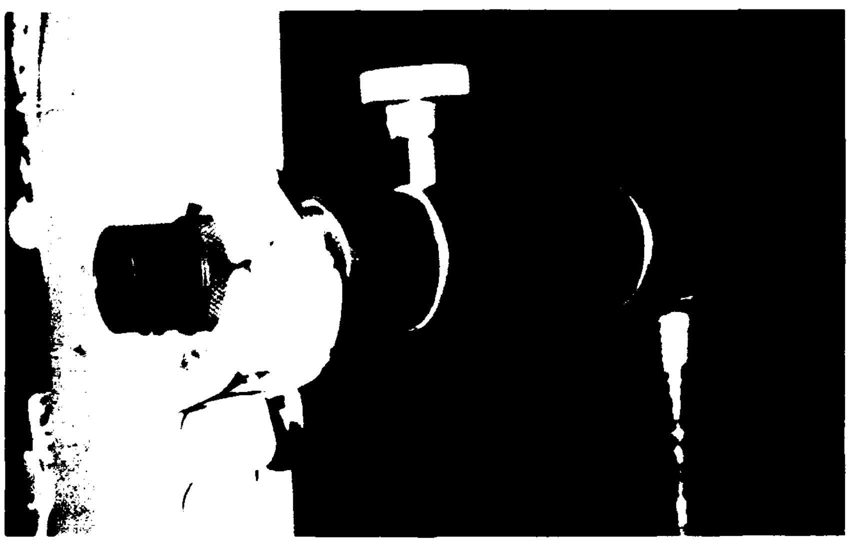

Figure 20. Modified Horton Bracket knobscrews (without connecting chain).

2. Aeromedical Pole and Waters Bracket. These devices worked well, and were very practical for aeromedical equipment items requiring a horizontal axis mounting surface. In the current aeromedical equipment inventory, these include the Catalyst Research MiniOX III oxygen monitor, Medical Technology Products Model 1001a infusion pump, and Biochem Model 1040A pulse oximeter.

3. Waters Shelf. This device was generally considered to be the most versatile of all those developed and evaluated. It safely and effectively aided in securing any piece of medical equipment that would fit on its mounting surface, and weighs 22.7 kg (50 lb) or less.

CONCLUSIONS

There is a slight potential for hazard presented by the protruding thumbscrews on the original Horton Bracket, and it is relatively heavy. Neither of these drawbacks exist with the Modified Horton Bracket. The Waters Bracket will probably result in relatively high fabrication cost due to design complexity, and also cannot be used on C-130 aircraft. However, provided the devices are fabricated and used as specified in this report, all 5 devices are safe, effective means for securing selected aeromedical evacuation medical equipment items.

RECOMMENDATIONS

We have received numerous inquiries and favorable comments regarding these devices, particularly from aeromedical crewmembers. Most of the inquiries have been regarding the modified Horton Bracket and the Waters Shelf, specifically about how to obtain design plans for fabrication. We recommend that, to obtain a high degree of quality and consistency, command or squadron logistics personnel consider contracting out to have these devices fabricated for general aeromedical evacuation use.

ACKNOWLEDGMENTS

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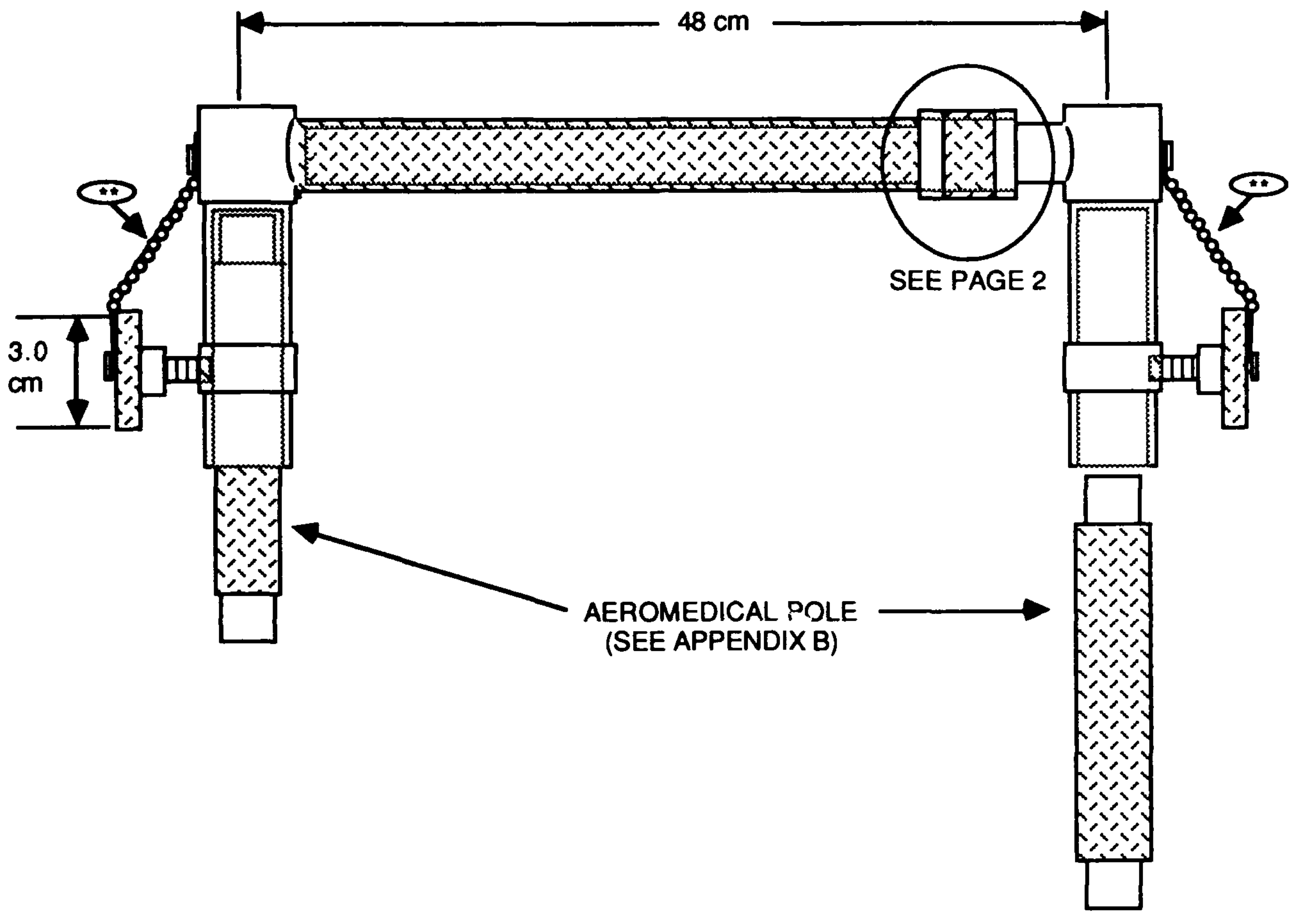
REFERENCES

1. Aeromedical Research Function Procedures Guide, USAF Armstrong Laboratory/CFTS, Brooks AFB, TX 78235, 1992.

2. MIL-STD-810D, Environmental Test Methods and Engineering Guidelines, Jul 83.

APPENDIX A. DESIGN PLAN FOR MODIFIED HORTON BRACKET



* plastic piece

** 15 cm silver bead chain

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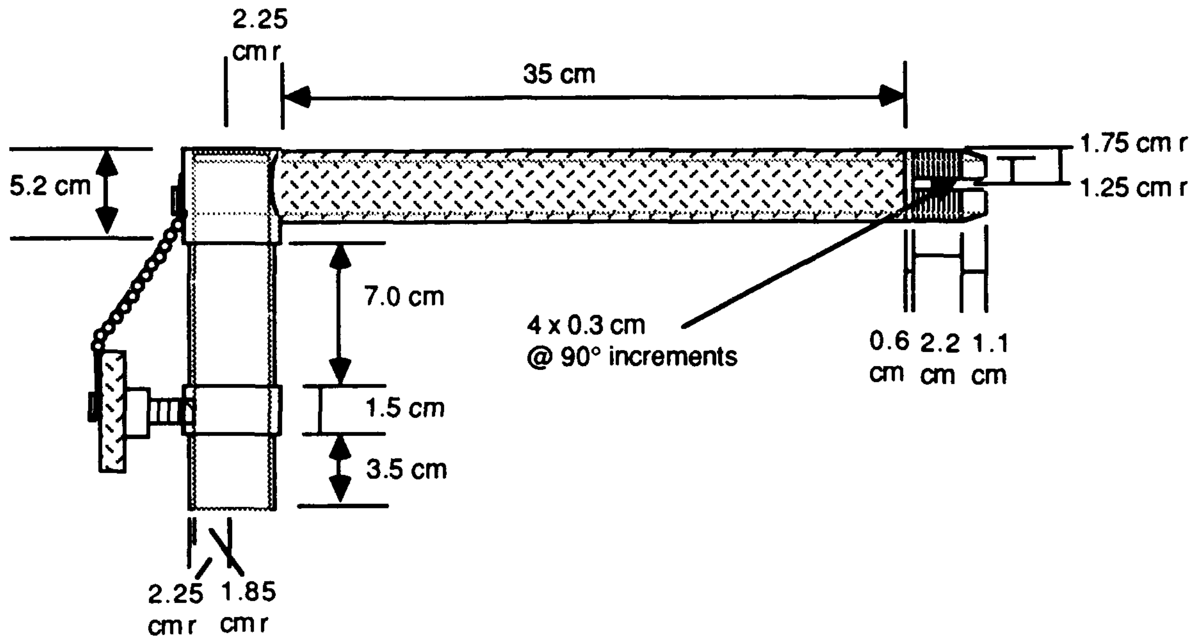
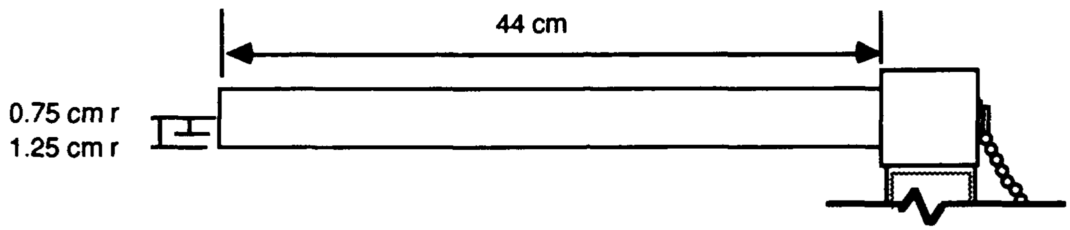
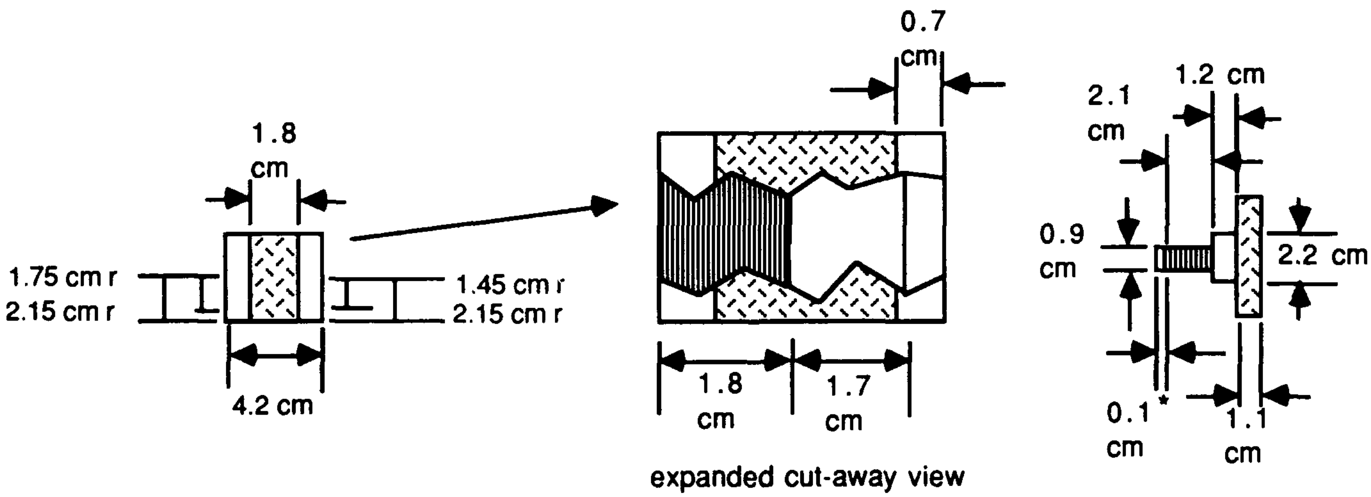
TITLE	DRAFTED BY	DATE
MODIFIED HORTON BRACKET	PHILIP J. PREEN	17 AUGUST 1992







r = a radius dimension

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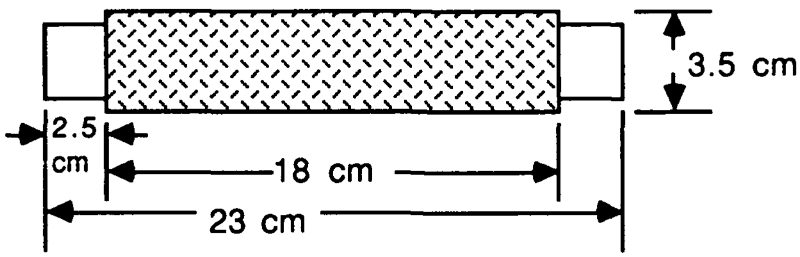
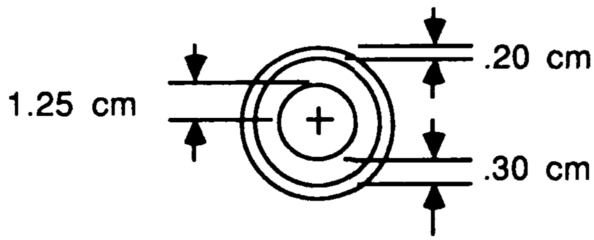
TITLE	DRAFTED BY	DATE
MODIFIED HORTON BRACKET	PHILIP J. PREEN	17 AUGUST 1992

APPENDIX B. DESIGN PLAN FOR AEROMEDICAL POLE



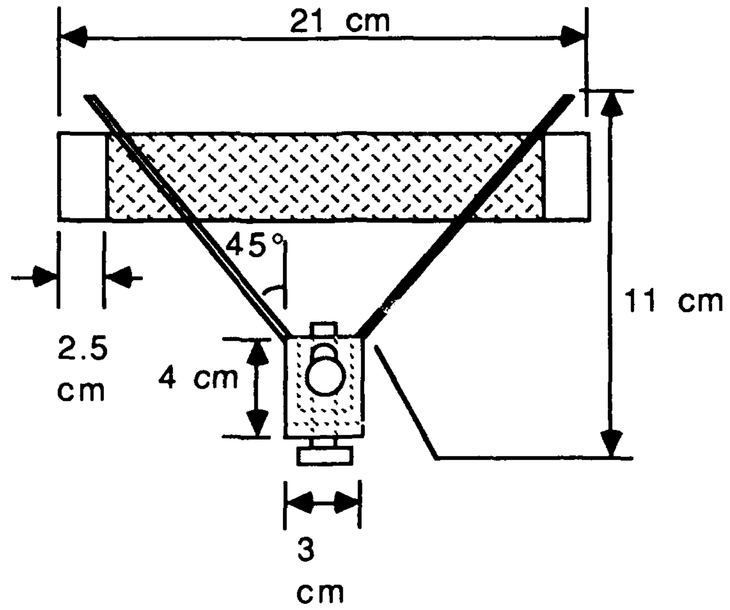
FRONT VIEW



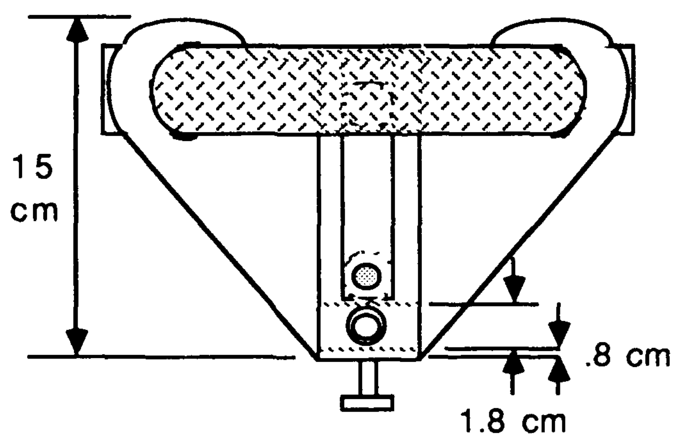
SIDE VIEW

TITLE	DRAFTED BY	DATE
AEROMEDICAL POLE	PHILIP J. PREEN	17 AUGUST 1992

APPENDIX C. DESIGN PLAN FOR WATERS BRACKET



TOP VIEW



FRONT VIEW

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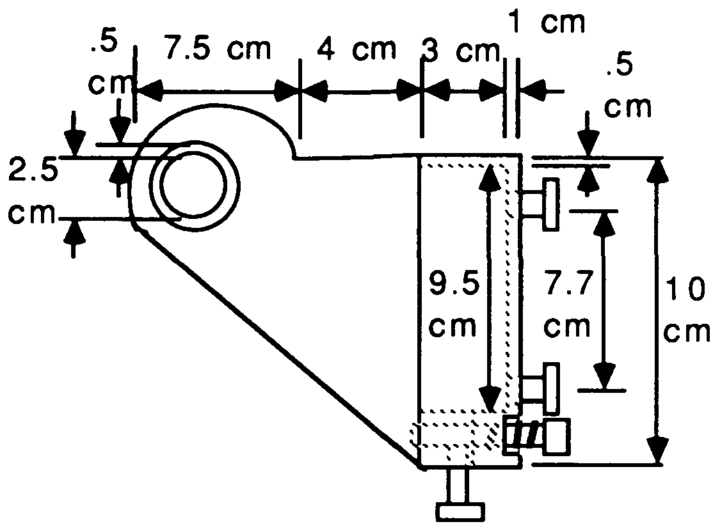
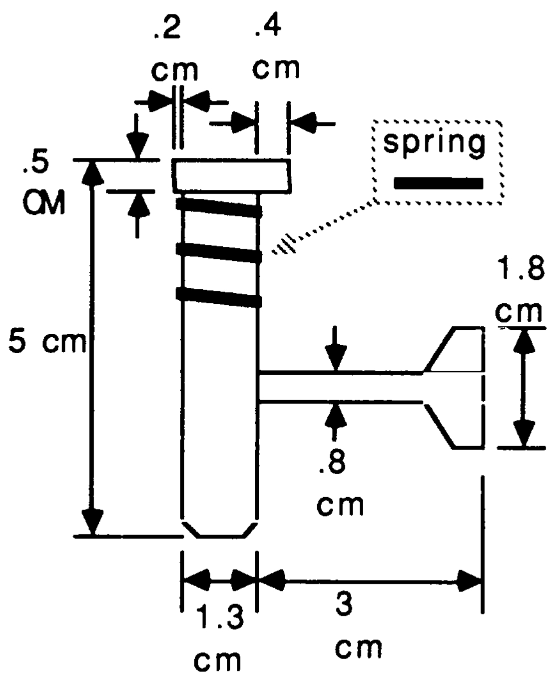
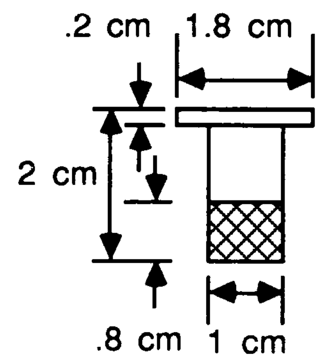
TITLE	DRAFTED BY	DATE
WATERS BRACKET	PHILIP J. PREEN	17 AUGUST 1992



SIDE VIEW





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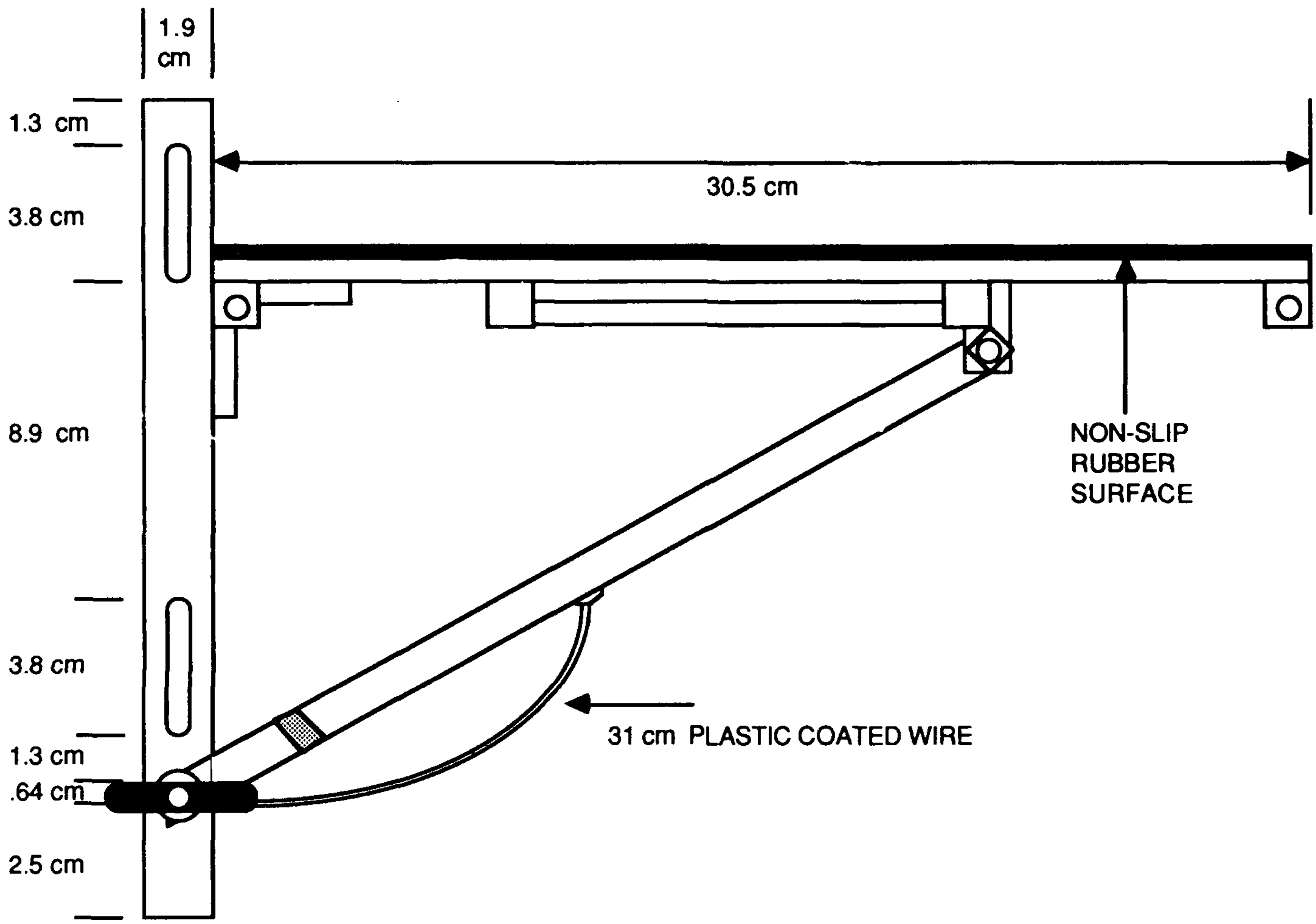
TITLE	DRAFTED BY	DATE
WATERS BRACKET	PHILIP J. PREEN	17 AUGUST 1992

APPENDIX D. DESIGN PLAN FOR WATERS SHELF



SIDE VIEW

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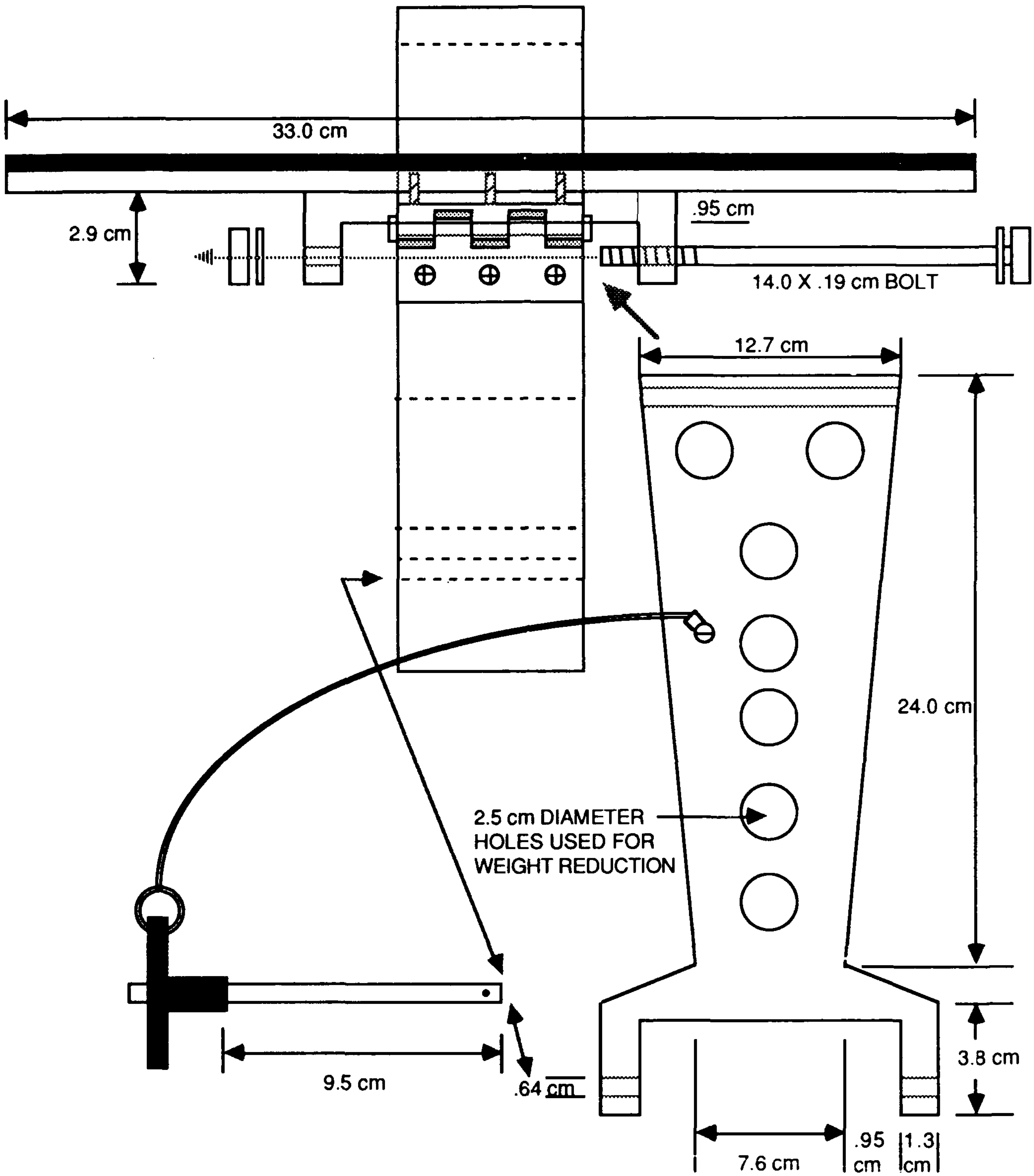
TITLE	DRAFTED BY	DATE
WATERS SHELF	PHILIP J. PREEN	17 AUGUST 1992



FRONT VIEW

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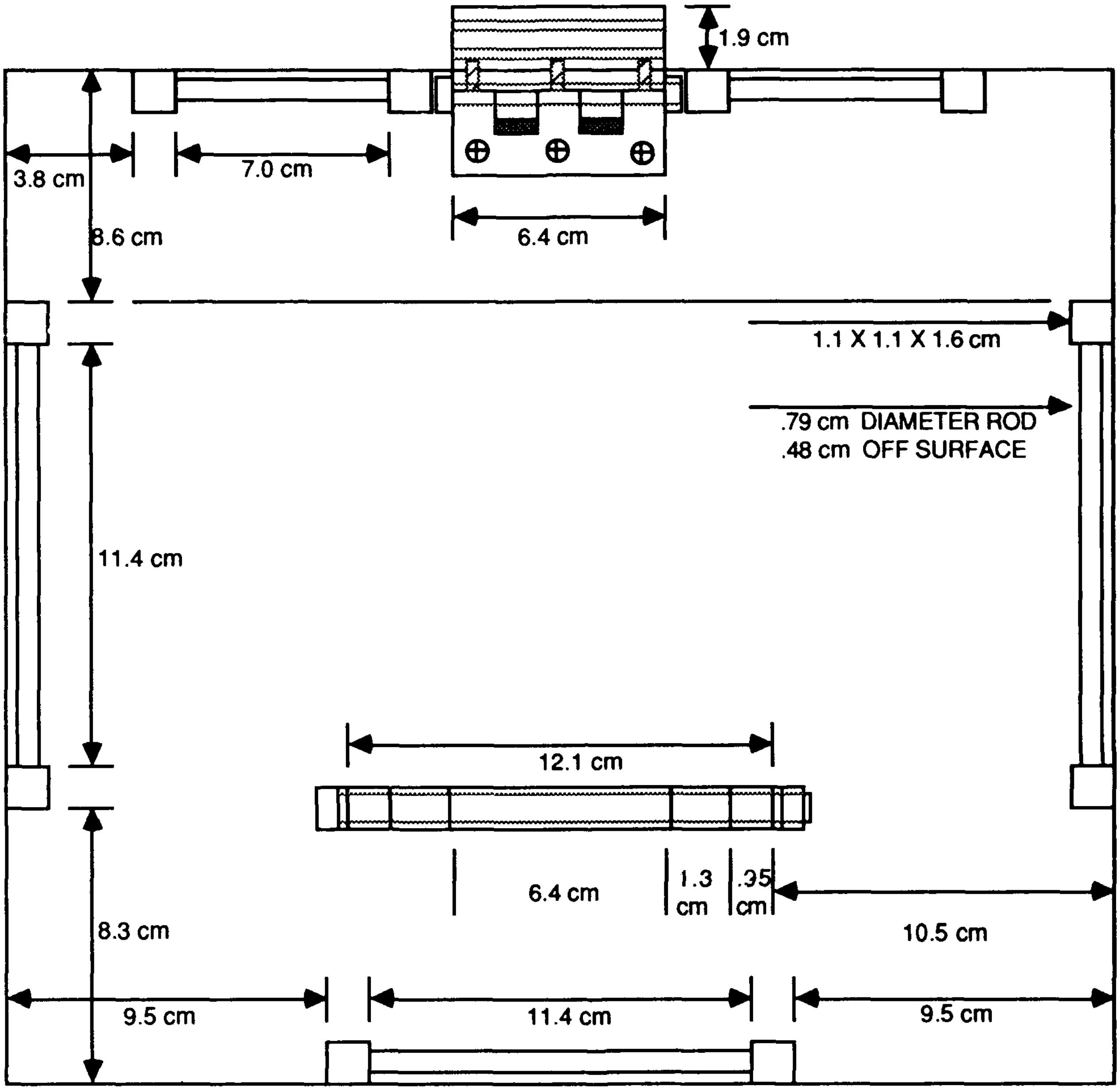
TITLE	DRAFTED BY	DATE
WATERS SHELF	PHILIP J. PREEN	17 AUGUST 1992



BOTTOM VIEW

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TITLE	DRAFTED BY	DATE
WATERS SHELF	PHILIP J. PREEN	17 AUGUST 1992

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